WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 51

TAFO, GHANA

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FIFTY-FIRST QUARTERLY REPORT

JULY-SEPTEMBER, 1958

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in W.A.C.R.I. Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb (returned from leave 5th August)
Deputy Director	C.G. Johnson
Scientific Assistant to Director	G.A. Jones (on leave 11th August)
Secretary	H.L. Pugh
Accountant	H.J.S. Mill (on leave 13th August)
Assistant Accountant	J.N.A. Hyde
Office Assistant/Librarian	D.J. Ellis (arrived 1st August)

TAFO STATION

Division of Entomology	C.G. Johnson
	P.F. Entwistle
	M.R. Smith (arrived 31st July)
	K.B. Armstrong (arrived 5th August)
Division of Pathology	J.W. Blencowe (on leave 1st September)
	A.L. Wharton (returned from leave 5th August)
	A.A.F. Brunt
	P.D. Turner (arrived 8th July)
	A. Attafuah
Division of Botany	D.R. Glendinning (returned from leave 2nd September)
	R.G. Hurd (on leave)
Division of Chemistry	R.H. Kenten
	R.K. Cunningham (on leave)
Division of Agronomy	R.W. Smith
Statistician	C. do Jonge
Laboratory Technicians (electronics)	A.J.H. Arnold
(spectrography)	J.C. Burridge
Plantation Manager	H.W.S. Allison
Maintenance Engineer	A. Maddison
Works Superintendent	E.K. Berko
Guide-Demonstrator	F.E. Decker
Station Manager	S.E. Ntim-Kwafo
Medical Officer	P.K.K. Knudson

IBADAN SUB-STATION

Deputy Director (Nigeria)	T.W. Tinsley
Entomologists	R.G. Donald
	C.K.H. Martini
Pathologists	J.M. Thresh
	D. Kay (on leave 26th July)
Agronomist	J.F. Longworth

STAFF MATTERS

The Director attended the Seventh Meeting of the Inter-American Cacao Conference held at Palmira, Colombia, in July, and also visited the Instituto Interamericano de Ciencias Agricolas, Turrialba, La Lola Experimental Station for Cocoa, Costa Rica, and the Imperial College of Tropical Agriculture, Trinidad. He returned to Ghana on the 5th August.

Dr. Johnson assumed the duties of Acting Director during the Director's absence.

Dr. M.R. Smith, and Mr. K.B. Armstrong, Entomologists, Mr. P.D. Turner, Mycologist, and Miss D.J. Ellis, Office Assistant/Librarian, joined the Staff during July and August. Mr. G.A. Jones, Mr. H.J.S. Mill and Mr. D. Kay (Nigeria) went on leave and Mr. A.L. Wharton returned from leave during the quarter.

Mrs. J. Nicholas, who had temporarily filled the post of Office Assistant/Librarian, returned to the United Kingdom early in July.

VISITORS

There has been a large number of visitors to Tafo during the quarter: they include Mr. D. Rhind, Secretary of Agricultural Research, Colonial Office; Mr. E.H.C. Heritage of the Cocoa Marketing Co., London; Mr. Ford Milan, Agricultural Attaché, U.S. Consular Service; Mr. W.H. Rodgers, Colonial Development Corporation, Borneo.

A party of students from the Imperial Defence College accompanied by Major-General A.G. Paley, G.O.C. Ghana Army and Mrs. Paley also toured the laboratories and station; the delegates from the Scientific Council for Africa (South of the Sahara) also visited Tafo. Other parties were 30 members of Cadbury's Senior Staff (Ghana), and Messrs. Richard Carrickford & Co., British Film Unit; Mr. G.E.K. Ekuban, Ghana Cocoa Marketing Board; M. Juan Alonso Puertas, Director/Engineer of Agriculture, Fernando Po; M. Francisco Miguel de Sola, Vice-President, Agricultural Chamber, Fernando Po; M. Jose Marie Camprubi, Camprubi-Balet, Agric. Rio Muni, Spanish Guinea; M. Alfredo Jone Jones Niger, Fernando Po, M. Miguel Llompart Aulet, Fernando Po.

Dr. M.F. Chandraratna, Director of Agriculture, Ceylon; and Drs. C.R. Panabokke and S.K.A. Weerawickrema, Agricultural Research Officers, Ceylon; Messrs. Sape and Owusu, Ghana Cocoa Marketing Board Agricultural Research Students in Germany; David Bowyer and David Croft, British Scouts.

The Institute was visited also by students from various schools and colleges in Ghana and students from St. Luke's College,

Ibadan, Nigeria. In addition several parties of Agricultural Survey Officers and Agricultural Field Assistants on refresher courses at Bunso and Learners from the Agricultural Training Centre were conducted round.

MANAGEMENT AND MAINTENANCE

Residential Area

Levelling, stumping and clearing in the residential area has continued and grass is being established on new bungalow sites. Decorative plants received a set-back due to the unusual dry weather. Two Hayters were purchased and put to effective use on the golf-course.

Transport

Six of the old vehicles were disposed of and five new ones bought, including an Austin Omni-Van and a tractor (Massey Ferguson 65) were purchased.

Vegetables and Food Crops

3,080 lbs. of fresh vegetables were produced compared with 603½ lb. in the previous quarter.

Buildings

Apart from the usual routine maintenance of all buildings and roads the Dispensary has now been extended to cope with the increased number of patients attending the Medical Officer, the Spectrographic Laboratory and New Fermentary progress towards completion and the Police Barracks have been completed.

CROP DELIVERY

The number of pods harvested during the quarter is given below:

Month	Old Station	Square Mile	Total
July	7,325	16,177	23,502
August	3,783	20,870	24,653
September	65,552	82,000	147,552
Total	76,660	119,047	195,707

Selected Amazons have been planted as basket seedlings (3,846) in 10 acres in Block H and a further acre with 460 Amazon basket seedlings in Block D.

SWOLLEN SHOOT DISEASE

The number of trees removed from the Station farms during the quarter due to swollen shoot infection and other causes are shown in the table below:

Month	Trees destroyed		Total	Total Seedlings removed
	Swollen Shoot	Undiagnosed		
July	34	2	36	58
August	65	5	70	97
September	35	-	35	37
Total	134	7	141	192

UPPER AMAZON SEED

A total of 11,009 pods were issued to the Division of Agriculture at Bunso during the quarter, against replacement with Amelonado cocoa. The following table also shows distribution of Amazon cocoa sent to other stations outside the country.

Date	Pods	Destination	Remarks
29-8-58	2,000	Br. Cameroons	Sent as seed
20-9-58	50	Sierra Leone	Sent in pods
26-9-58	40	Nyasaland	Sent as seed
28-9-58	3,610	Ibadan	Sent in pods
Total	5,700	-	-

METEOROLOGY

Rainfall in inches and the number of wet days for the quarter compared with the past 20-year means is given below:

Month	1958		20-year mean	
	Rainfall (in.)	Wet days	Rainfall (in.)	Wet days
July	0.20	5	5.77	14.1
August	1.52	5	2.49	13.1
September	2.26	10	6.10	14.8
Total	3.98	20	14.36	42.0

T A F O S T A T I O N

PATHOLOGY DIVISION

VIRUS RESEARCH

Studies on the Gandahun isolate from Sierra Leone (Quarterly Report No. 50) are continuing. Some four-month-old seedlings infected at the bean stage with this isolate have developed pronounced root swellings and stem swellings appear to be forming. Experiments on the effect of the Gandahun isolate on the growth of Amelonado seedlings are in progress.

Fourteen isolates of the Swollen Shoot group of viruses and one of the Mottle Leaf group have shown marked differences in their effects on the growth of Amelonado cacao seedlings as measured by plant heights, leaf measurements, and wet and dry weights of leaves, stems, tap and lateral roots. Swellings also occurred. Preliminary statistical analyses of data from all the 4 replicates yielded highly concordant results, the transgressional probability being less than 0.1 per cent. Bisa, Amafie and Wiasi isolates have the least and New Juaben and Bosomuoso have the worst effects on seedlings. Similar particulars for a new virus isolate would enable its appropriate position in the ranking of the 15 isolates to be determined together with the severity of its effect on seedlings. Similar experiments have begun, with isolates of the Mottle Leaf group.

The results of an experiment on the effect of unrelated isolates, when present singly and as a complex, on the growth of Amelonado seedlings are now being analysed.

Attempts are being made to establish Cuscuta chinensis, C. campestris and C. subinclusa on cacao seedlings and on other herbaceous species. If establishment is successful, dodder-transmission of cacao virus isolates will be attempted.

Insect transmission studies

The ability of ten vector species to transmit fourteen unrelated cacao virus isolates is being investigated. Apart from results recorded in previous reports, Pseudococcus concavocerarii James has transmitted the Nkawkaw, Bosomtwe and Mampong isolates while the Yaakase isolate has been transmitted by Planococcus citri (Risso) and the Nkawkaw isolate by Ferrisiana virgata (Ckll.). The Gandahun isolate from Sierra Leone has been transmitted by a second vector, P. citri, and the Bisa isolate has now been transmitted by F. virgata (see report of unsuccessful attempts in Quarterly Report No. 50).

In virus isolation trials, using single individuals of P. njalensis, some of the plants infected with Kpeve, Amafie, Sedi-Nkawie and Nsaba have shown only very mild symptoms through four to five flushes. It is not known whether these symptoms are induced by mild strains, and tests are now proceeding to determine whether the mild symptoms can be reproduced when transmitted to healthy cacao.

Host range investigations

In view of the proposal to test the Ceiba pentandra Gaertn. found on the site of the Gandahun (Sierra Leone) outbreak, laboratory tests are being conducted to determine whether this and other related species are susceptible to this isolate.

As a result of clear-felling operations in areas of the Square Mile during the past few months it has been possible to observe trees known to be susceptible to cacao viruses soon after felling. No apparent signs of virus-infection were found and insect transmission tests to cacao beans have failed to reveal virus infection in any of the trees so far tested. These field surveys will be continued when clear-felling operations are resumed.

STUDIES ON BLACK-POD DISEASE

Fungicide spray control trials

Mid-crop pickings on the three field experiments incorporating fungicides to control black-pod disease have been small. There are, so far, no treatment effects on yields of wet beans which, in these experiments, are being taken as the final measure of control.

Pod susceptibility experiment

At the beginning of the year 150 of the trees on this experiment were split into pairs to study the development of young fruits protected from infection by Phytophthora palmivora Butl. (cf. 48th Quarterly Report). All fruits on one tree in each pair are being sprayed, at weekly intervals, with a strong concentration of Perenox, with the object of completely eliminating spore infections. Only 3 "black-pods" have been recorded on these trees compared with 51 on the untreated. Figures for incidence of cherelle wilt on sprayed and untreated trees have not yet been summarized. Compared with the two previous years, incidence of disease on the untreated trees has been extremely low.

Resistance and tolerance

Recording of all trees on the 1st Clonal Trial and 9th Progeny Trial continues. Selections from the 1st Clonal Trial are being tested in the laboratory for tolerance, following

artificial wound infections. Compared with last year there has been a very rapid build up of disease on plots in the 9th Progeny Trial and there may be sufficient data at the end of this season to compare the selections for field resistance.

MINOR DISEASES OF CACAO

In a preliminary investigation of minor fungal diseases of cacao isolations were made from fruits at all stages of development. Diseased cherelles and immature pods yielded only a species of Fusarium, but a large number of fungi were recovered from diseased ripe pods. They included Aspergillus niger van Tiegh., Botryodiplodia theobromae Pat., Cephalosporium acremonium Corda, C. humicola Oudem., Cephalosporium spp., Curvularia sp., Fusarium spp., Gliocladium penicilloides Corda, G. roseum (Link) Thom, Helminthosporium sp., Hormodendrum clodosporioides (Fres.) Sacc., Mortierella sp., Mucor sp., Nigrospora sphaerica (Sacc.) Mason, Penicillium spp., Pestalotiopsis sp., Phycomyces sp., Phytophthora palmivora Butl., Rhizopus nodosus Namyslowski, Trachysphaera fructigena Tab. & Bunt., and a Verticillium sp. The majority of these fungi appear to be saprophytic or weakly parasitic. Inoculation tests of some are being made to determine if they can cause pod rots with symptoms distinct from those of black-pod disease.

MYCORRHIZA

Work on the isolation and occurrence of possible mycorrhiza of cacao has been re-opened (Rep.W.Afri.Cocoa Res. Inst., 1953-54, pp.23, 50; 1954-55, p.76).

ENTOMOLOGY DIVISION

JOINT WACRI/DIVISION OF AGRICULTURE CAPSID CONTROL TRIALS

The trials in the Eastern Region and in Ashanti on the comparison of Endrin, gamma-BHC, and Aldrin continue; detailed results will be reported in due course.

LABORATORY ASSESSMENT OF INSECTICIDES

Many problems connected with the action of insecticides in the field - e.g. persistence, the absorption of insecticides by foliage and the possibility of a partial systemic action by the chlorinated hydrocarbons, taint, the incorporation of resins in sprays, etc. are now being approached through work in the laboratory closely associated with work already in progress in the field.

Preliminary investigations have begun into the efficacy of various gamma-BHC formulations, and a comparative laboratory bioassay technique, using capsids, is being established. For this a continual supply of these insects is essential, but so far a satisfactory breeding technique with small breeding chambers, has not been found; an insectary has therefore been modified to attempt "mass breeding" under conditions approaching those in the field.

EARIAS STUDIES

On some plots of young cacao where shade has been considerably reduced, the terminal buds have been destroyed on a considerable scale by the larvae of the Lepidopteron, Earias biplaga Wlk. The general effect has been to cause an outgrowth of lateral shoots whose buds in turn become destroyed; the result is a bushiness and malformation of the young trees.

Work on the incidence, life history, and general ecology of Earias has been started with a view to rationalizing control measures. We do not lose sight of the fact that alteration in methods of cocoa establishment especially as regards the degree of shade may bring with it this and perhaps other pests in proportions greater than hitherto encountered.

MEALYBUG STUDIES

Oyoko

The second application of the double dieldrin treatment, begun in June, 1958, was completed during the present quarter. Ant populations fell rapidly to a level similar to that recorded after completion of the first treatment in 1956/57. Mealybug populations also declined, following ant control, and during the month of September no adults of Pseudococcus njalensis were found in counts to hand height on the trees.

In the untreated area mealybug populations are following a natural seasonal decline, though their numbers have not decreased to anything approaching those of the treated area.

Ant/Mealybug Control Trials - Series II

Between 5th and 12th of August dieldrin and dieldrin/coumarone, were applied to the appropriate treated area plots (see Quarterly Report No. 50). Ant populations were immediately affected but to an extent which did not differ appreciably between the two insecticidal treatments. The reasons for this unexpected event are being investigated in the laboratory.

Mealybug populations have also declined but it is as yet too early to say if these show any differences between the two

treatments.

MARMARA STUDIES

Populations of this moth (Lepidoptera, Gracillariidae) have begun a natural seasonal increase coincident with the beginning of the main-crop period.

Under natural conditions Marmara appears to be held in check by three species of parasitic Hymenoptera, of which the adults of two have been reared and despatched to U.K. for identification. During peak populations the rate of parasitism is extremely high, being in the region of 60 per cent, the greater part of which is due to an endoparasitic chalcidoid. In addition to this a further 18 per cent have been recorded as dying from unknown causes.

MINOR PESTS

Scolytoidea

In addition to those species mentioned in Quarterly Report No. 49, the following have now been recorded from cacao in varying stages of morbidity:-

Xyleborus collarti Egg.	(Scolytidae)
Hypothenemus ater Egg.	(Scolytidae)
Doliopygus V-grandis Samp.	(Platypodidae)

Xyleborus camerunus Hgd., mentioned in Quarterly Report No. 49, was mis-spelt there as X. cameroonus Hag.

BOTANY DIVISION

Favourable reports on the quality of many of our new varieties have been received from C.S.A.C. in England and the Walter Baker board in the U.S.A.; comments from Swiss manufacturers are awaited.

Discussions with the Division of Agriculture (Ghana) regarding the design and siting of seed gardens have been held.

A trial to compare the F1, F2 and F3 generations of T82 (Na32 x Pa35) was planted in May and has not previously been reported. It is in 12-tree plots with ten replications at 8 ft. spacing and six at 12 ft. spacing. Of the replications at 8 ft. spacing three are on very poor sandy soil, and arranged as a latin square. There is also an area at 8 ft. spacing on sandy soil with single-tree plots. It is thought that if there are differences in vigour between the generations they may be more

pronounced at the closer spacings due to competition, further augmented on the poor soil, and at a maximum in the single-tree plots on poor soil. The F2 pods were taken from a number of our F1 trees, and the F3 pods were obtained from a number of Division of Agriculture plots.

An experiment was made from November, 1957 to May, 1958 in which seedlings of six varieties were grown crowded together in boxes. They were four of the varieties in the 2nd PTA and two inbred lines from one of them. The relative performances of the four varieties, as mature plants, are known; and it seems reasonable to expect a poorer performance from the inbreds. Marked differences in their performances as seedlings were found, and on the whole these correlated with the performances as mature plants. Some data are given below -

		Seedlings sown in November			
Variety	Yield of mature trees	Mean dry wt. in May (g.)	Stem diameter in April (cms.)	Stem Height in April (cms.)	No. leaves in April
TF1	529	5.49	.665	31.5	15.2
K5	452	6.70	.703	31.1	16.1
S45	317	5.00	.612	31.3	14.0
A62	239	2.32	.539	16.5	9.6
K5 inbred 1	-	3.94	.522	29.0	14.1
K5 inbred 2	-	1.86	.475	14.7	8.6

The yield given is the estimated yield in ounces of wet cocoa per tree over 11 seasons, 1945 to 1955 inclusive. The seedling data is based on 12 seedlings of each variety.

It will be seen that K5 is doing rather better as a seedling than TF1, while TF1 is the better yielder as a mature plant. Apart from this, however, the results from the seedlings correlate fairly well with the yields or, for the inbreds, the expected performance. There is a marked unexpected difference between the two inbreds, and if substantiated would provide an interesting suggestion that vigour is at least partly under major-gene control. However, there was one main fault in the design of the experiment. All seed of a variety used was from one pod, and what appear as differences between varieties could be in part differences in the condition of the seed. The experiment is being repeated this year.

Besides the repetition of the above experiment, in view of the hopeful nature of the results, numerous comparisons of seedling vigour are being made in the nursery this year.

AGRONOMY DIVISION

UNIFORMITY TRIAL AREA, OLD STATION

Two pickings of the main crop harvests were completed during the quarter. The third picking which began on the 23rd September is in progress. Figures for the two pickings which include pods for Plant Pathology black-pod disease experiments are shown in the following table.

Date of Picking	Total Pods		% Pods Discarded	Pods Fermented	Wet Wt. of * Beans (calc.)	Dry Wt. of Beans
	Harvested	Discarded				
1958						
Sept. 1- 5	16342	746	4.6	15596	3119.2	1299.6
" 9-15	9924	456	4.6	9468	1893.6	789.0
Total	26266	1202	4.6	25064	5012.8	2088.6

* Wet weight was assessed on the basis of 5 pods to a lb. and dry weight on the basis of 12 pods to a lb.

SQUARE MILE

Experimental Plots

All cultural operations in the experimental plots and harvesting of pods were carried out regularly throughout the quarter. Yields in pods from all the various plots for the quarter are given in the following table and compared with those of the previous quarter.

Experiment	September Quarter	June Quarter	Grand Total
U.A. Spacing & Pruning	11073	15289	26362
U.A. Extension	2183	2860	5043
U.A. Multiplication	9171	7732	16903
Amelonado Spacing Trial	19947	11886	31833
Factorial Fertilizer Trial	854	1644	2498
2nd Establishment BI	1455	1787	3242
" " BII	2550	6615	9165
Uniformity Trial	7240	8519	15759
R.P.R. 'C' - A24	1615	532	2147
Amelonado Source Trial	673	462	1135
Shade & Manurial	19748	8673	28421
Total	76509	65999	142508

SHADE AND MANURIAL TRIAL

The results, until the end of September this year, are given below:

	No. of Pods	Dry Cocoa (lbs.)
Shaded Unmanured	3003	268.1
Shaded Manured	4200	368.4
Unshaded Unmanured	6231	438.8
Unshaded Manured	6990	510.2

AMELONADO SPACING TRIAL

The condition of the cocoa is excellent, and a heavy crop is expected this season. The $7\frac{1}{2}'$ x $7\frac{1}{2}'$ spacing is again superior to all others.

FOREST TREE NURSERY

The nursery was kept in a sound condition throughout the quarter, despite the long spell of dry weather. 3,000 seedlings of Terminalia ivorensis have been established in baskets, prior to planting out as shade on a new 33 acres fertilizer trial.

COVER CROP AND MULCHES EXPERIMENT

All treatments under this experiment have made good progress, more especially since the rains started.

FERTILIZER APPLICATION

The second application of fertilizer on the selected areas of the square mile was completed from the second week to the end of September. This application consisted of 35 lbs. of nitrogen per acre as urea.

CHEMISTRY DIVISION

SOIL FERTILITY

Field Experiments

Routine maintenance was continued and mid-crop harvesting completed. The shade and manurial trial yield trends followed those of season 1957-58 (Quarterly Report No. 48; see also p.12 of this report). The second dressing of nitrogen was applied in September where required.

Pot Experiment

The pot experiment with 5 degrees of shade and 2 nutrient levels continues. Monthly height and leaf area

measurements have been taken.

Laboratory Work

Physical and chemical analysis of different cocoa soils continue. Nitrification studies are now in their second year. Soil moistures and temperatures under different shade are still being carried out. The analysis of healthy and mineral deficient cocoa leaves has been completed.

COCOA PREPARATION AND QUALITY

Work on methods of fermenting and drying small quantities (30 lb. - few ounces) of beans is continuing. One of the difficulties in this work is the wide variation in quality which can occur among batches of finished beans from different experiments run under apparently identical conditions. This variation is probably due to the choice of experimental conditions which do not allow rigid control of the variables (e.g. when the beans are not kept sterile) and partly due to the inherent heterogeneity of the raw material which becomes increasingly serious with diminution in the size of the sample. Variation due to the latter factor can be overcome by increasing the size of the sample but it is then more difficult to ensure that each bean is being exposed to closely similar conditions.

I B A D A N S U B - S T A T I O N

STAFF AND STATION MATTERS

D. Kay (Mycologist) proceeded on leave on July, 26th. P.O. Park and E.C. Hislop visited the Cameroons 15-16th July, and a report on their visit has been distributed.

Contracts have been sealed and work is proceeding on a house for the Deputy Director (Nigeria) and for an additional staff bungalow. These houses are nearing completion and should be available for occupation soon. Some difficulty in obtaining materials has been experienced with the six insectaries but these have now arrived and little further delay is expected.

VISITORS

The Federal Minister of Research and Information, The Hon. V.E. Mukete, accompanied by Mr. D.J. Parkinson, visited the Sub-station in August. Other visitors have included Dr. Raub Snyder, Vice-President, International Development Services Inc. New York, Professor P.J. Du Toit, Union of South

Africa, Professor J. Lebrun, Secretary General of I.N.E.A.C. Belgian Congo, Mr. F. Hendrickx, Scientific Secretary C.C.T.A./C.S.A., Chief Obisesan, and Dr. J. Sellschop, Union of South Africa.

PATHOLOGY SECTION

Dale H.A. RAM. 17, p 224

VIRUS RESEARCH

The effect of Cacao Swollen Shoot Virus on Trees

The condition of virus infected cacao trees is almost invariably worse than that of adjacent healthy ones (Baker & Dale, 1947; Cope, 1953; Benstead, 1953). Indeed observations in Ghana showed that the most virulent strains caused a drastic decline in the yield of mature trees, which were killed in two or three years (Crowdy & Posnette, 1947; Posnette & Todd, 1955). This has usually been attributed to the primary effects of virus, but insect pests were not controlled in the Ghana experiments and it is known that capsids and die-back fungi and possibly thrips build up and cause extensive damage to trees which have been weakened by previous virus infection (Williams, 1953). Moreover, field observations show that infected trees persist longer in favourable conditions than they do elsewhere. This suggests that the deterioration of virus infected trees is partially determined also by associated pathogens and environmental conditions.

This possibility can be tested for the first time now that efficient methods are available for the chemical control of capsids and other insect pests. The first experiment was carried out at Koroboto where the spread of a naturally occurring outbreak in peasant cacao has been followed by regular monthly observations since September, 1953. Yield records have been taken for each of the 827 trees since August, 1954 and losses due to black pod disease have been negligible since fungicide spraying was introduced in August, 1955. No valid statistical analysis of the results is possible as positional effects are confounded with other variables, but the first year's results suggested that virus infection was reducing yield according to the length of time the trees had been showing symptoms. This result was consistent with observations on the condition of the trees, as most of the infected ones were chlorotic with particularly severe capsid damage, defoliation and dieback. A ground

vegetation largely consisting of coarse grasses was also invading the plot which resembled several others in the vicinity similarly affected by capsids and swollen shoot disease.

Routine monthly spraying with gamma-BHC, primarily against capsids, was started in January, 1956 and the trees have subsequently shown a striking recovery, even though the percentage virus infection on the plot increased from 24.4 to 63.7 in July, 1958. Many of the dead branches have fallen and the trees have made extensive new growth from the remaining relatively undamaged parts. Thus the canopy has been largely restored and the ground vegetation has virtually disappeared, while the crops have increased even though regional production declined in the last season. Adjacent farms beyond the drift effect of the spray continued to deteriorate and some have been abandoned and are now being used for food crops.

Several different virus strains occur at Koroboto and they differ in the severity of the symptoms they cause, but typical ones have a marked effect on the growth of seedlings infected as beans in laboratory tests. Thus the yield and growth of infected trees is probably suboptimal in spite of the recovery due to spraying. Nevertheless the effect of virus is clearly not lethal in this area on well maintained farms sprayed against capsids and it is probably no greater than that due to variation in soil, shade or other environmental factors.

The virus strains at Koroboto resemble those occurring at numerous outbreaks in Nigeria and there is no reason to think that the results obtained there are all atypical. Indeed similar recovery has already been noted elsewhere. These results are of obvious importance and affect Departments of Agriculture policy in the abandoned areas of mass infection and elsewhere. Further work is clearly justified in Nigeria and Ghana, where particularly virulent strains have been reported. Spraying has already commenced at several other farms and additional work is also planned to elucidate the interaction between cacao swollen shoot virus and the dieback fungus Calonectria rigidiuscula (Berk. & Br.) Sacc. on the growth of seedlings growing under different cultural conditions (see Agronomy report). It is at least possible that the effect of even the most virulent strains, is largely determined by the shade, soil and other conditions under which attacked trees are growing.

Cacao Swollen Shoot Virus Complex in Nigeria

Virus isolates have been taken from some of the many outbreaks of cacao swollen shoot disease which have been discovered

in Nigeria. They cause leaf symptoms which show consistent differences in type and severity and they are usually associated with swellings on roots and stem, or on the roots alone. Isolates from widely different localities show the greatest differences in symptom expression. Moreover they rarely protect against each other indicating that they are not closely related. By comparison different isolates from the same tree, outbreak or locality, usually protect against each other and cause symptoms which differ in severity but not in type.

This situation with "macro-differences" between isolates from separate localities and "micro-differences" between isolates from within them is similar to that already described in Ghana. In each country the most intensively studied isolates can be most conveniently grouped on the results of protection tests and the isolates in each group are apparently closely related strains which show mutual protection, but no relationships with isolates from other groups.

The differences in virulence between isolates from the same trees and outbreaks make it impossible to recognise the typical isolates from a given locality unless an extensive series of transmission tests is carried out. This has not always been done and in both Ghana and Nigeria laboratory cultures have sometimes been given locality names on inadequate evidence. Moreover they have often proved to be mixed inocula containing both mild and severe strains. This has been demonstrated by single insect transfers from plants graft-infected with many Nigerian isolates. These frequently segregate into strains showing consistent differences in virulence and symptom expression. Consequently the more intensively studied isolates are now being carried on by repeated single insect passages in an attempt to obtain stable cultures which can be used to increase the precision of subsequent experiments. Both mild and severe strains from Egbeda are now giving consistent symptoms, but with single insect transfers it has been noted that the usual symptoms of the severe strains often fail to appear until the second flush produced after germination.

All previous studies on the strains occurring within swollen shoot outbreaks have been on large ones occurring in areas of mass infection. Consequently it is not clear whether the different strains appear by mutation, segregation from an initial mixed inoculum, or by spread from more than one centre of infection. As an experimental approach to this problem,

transmissions are now being carried out to determine the strains present in all the trees within several small, discrete outbreaks found in areas remote from the large centres of infection. Attempts are also being made to determine whether individual mealybugs may simultaneously transmit related strains and how quickly these are resolved on successive passages.

Virus - Free Budlings from Infected Trees

Numerous observations in Ghana and Nigeria show that patches of bark from trees infected with cacao swollen shoot virus do not always infect grafted seedlings. This is usually because the explanted tissues die at grafting or soon afterwards. However, some patches form a permanent union and persist indefinitely, yet do not cause symptoms. This suggests that they do not contain virus, this being incompletely systemic in the original source. The possibility has already been investigated by Dale (W.A.C.R.I. Annual Report 1956-57, p.29) but his efforts to obtain healthy cuttings and budlings from infected clones were all unsuccessful.

In the most recent work buds were taken from the various branches of large trees at I.N.A. farm which had been experimentally inoculated with a virus originally collected from Olanla. Some of the trees had been inoculated eight weeks previously and had only recently shown symptoms, which were few and restricted to a few main branchss. Other trees had been infected for many months and showed conspicuous and extensive symptoms. The grafted plants were cut back after grafting to stimulate the buds to develop and one shoot was also allowed to grow from each stock.

All twenty grafts from each of the old infections contained virus, which caused symptoms in the stocks and on all the budlings which developed. By comparison virus was demonstrated in only some of the patches from each of the recently infected trees. Indeed, budlings have been raised which have not only failed to infect their stock but have made vigorous symptomless growth for eight months. This strongly suggests that they are virus-free but as a final check they are being cut back and grafted with healthy buds. The new growth will then be kept under close observation for symptoms.

Effects on Growth as Criteria of Relationships between Isolates of Cacao Viruses

Holmes (Virology, 2, 611, 1956) has stressed that unrelated pathogens usually have cumulative effects on their host, when they are inoculated together. By comparison the effect of

two related strains is usually intermediate between that due to each one occurring alone. This suggests that observations on the effects of viruses on growth may be used as criteria of relationships and the technique has already been used with cucumber (loc. cit.) and ringspot viruses (Harrison, J. gen. microbiol. 18, 450, 1958); see also p.5 of this report.

The application of the method to cacao viruses is being investigated with various Nigerian isolates. In the first experiment groups of beans were infected with two isolates from the Egbeda area inoculated singly and in combination, and the subsequent growth was compared with that of comparable healthy controls. After eleven weeks the Koroboto and Ikire isolates reduced the mean leaf area by 23 and 33 per cent., respectively when inoculated singly and by 32 per cent. when inoculated together. These results suggest that the isolates show mutual interference and that they are related strains; a conclusion substantiated by the mutual protection demonstrated in conventional tests.

Similar results were obtained in a second experiment with closely related isolates from Ilesha and Olanla. These caused reductions of 29 and 35 per cent., respectively when inoculated singly and of 33 per cent. when occurring together. By comparison in a third experiment the Alaparun and Koroboto isolates which do not show mutual protection, appeared to have entirely independent effects on growth. They reduced growth by 22 and 25 per cent. respectively and by 38 per cent. when occurring together.

These preliminary results support the conclusion previously reached from protection tests that the swollen shoot complex of viruses in Nigeria contain some isolates which are closely related and others which are not. However, the technique is unlikely to have widespread application as a means of classifying the numerous isolates. This is because each test involves a large number of replicates and substantial insectary space. Furthermore, the inoculations have to be carried out by mealybugs which are inconvenient and tedious for large scale use.

Cacao Necrosis Virus

Transmission tests with cacao necrosis virus (CNV) have continued and 2 species of coccid from Cola nitida (Vent.) Schott & Endl. have been included but no transmissions have so far been recorded.

In transmission tests with mealybugs, some plants have shown necrotic symptoms on young developing leaves and others small transparent lesions along midribs. As no other symptoms have developed during 3 months of observation it is uncertain whether these are the initial symptoms of CNV in young plants. Therefore attempts have been made to inoculate one month old seedlings using leaf tissue-grafts. Though 50 per cent of the leaf pieces have taken, no reaction has been recorded during 5 weeks of observation. Seedlings about 10 months old, grafted with leaf tissue, showed the usual necrotic symptoms three to four weeks after grafting. Tissue taken from hard or soft leaves is equally suitable but no symptoms were observed when grafts were made with material taken from symptomless leaves of infected seedlings. Other experiments to investigate the various factors governing the occurrence of necrotic symptoms are still in progress and will be reported later.

Some Amazon seedlings grafted with patches from C. nitida at Omi-Aboderin have produced some small transparent lesions 3 months after grafting. Necrotic symptoms have been obtained on Amazon seedlings grafted with patches from C. nitida growing as far as 500 yards outside the outbreak at Omi-Aboderin; so that it now seems very likely that CNV spreads from C. nitida to cacao; areas which were cut out 3 years ago, have been visited, but no new infections seem to have occurred. Budwood was taken from both cacao and Cola and grafted on to Amazon seedlings. Only the ones grafted with patches from Cola showed necrotic symptoms. This may indicate that CNV is common in C. nitida but that its spread to cacao is rare.

Insect transmission of cacao virus isolates

Experiments to investigate the influence of repeated single insect transmissions on the expression of symptoms have continued. Plants with mild symptoms of the Balogun isolate have been obtained after the first transmission by single insects, with the Elepo isolate after three and with the Olanla isolate after five successive transmissions by single insects. From all source plants showing mild symptoms for the first time after single insect transmissions, severe symptoms were obtained by using 10 insects; but there are now indications that there is no immediate reversal from mild symptoms to severe ones after mild symptoms have been produced for several times in succession.

AGRONOMY SECTION

Agodi Cacao Experimental Farm

Routine maintenance has been carried out, including severe pruning of dead and senescent branches on old trees. Shade thinning has so far been confined to removing the lower branches of large Cola trees which were suppressing the adjacent cacao canopy, and a trial of an arboricide on several species of shade trees was started in July. No trees have died though some are showing signs of defoliation. Half of the farm was sprayed with Perenox, the unsprayed half providing black pods and pods without copper deposits, for experimental purposes. In this unsprayed area it was interesting to note that there was a considerable build-up of black-pod disease at the beginning of the rains, which declined to almost negligible proportions during a long, unusually dry spell in July and August. The following rainfall data from Agodi for January to September of this year are compared with the past 15 years monthly rainfall means at Moor Plantation. The two sites are seven miles apart.

Agodi Rainfall (ins.) 1958

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.---
0.13	1.87	2.35	4.60	9.85	9.16	0.06	2.36	2.37 ---

Moor Plantation, Monthly Rainfall means (ins.) 1943-57

Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.---
0.45	0.97	3.34	5.87	6.23	6.54	5.27	3.10	7.17 ---

Moor Plantation

Plots Y1 and C6. The trees have responded well to pruning, and Trinitario types especially are yielding well.

Koroboto

In conjunction with the Pathologist, two experiments were started in August at Koroboto, some twelve miles from Ibadan, in the area of mass infection.

Both experiments are of randomised block design, with various cultural treatments on the main plots associated with two virus treatments, and healthy controls. Each sub-plot is further subdivided, with and without inoculation with Calonectria rigidiuscula (Berk & Br.) Sacc. The planting material was Amazon and TN38 cacao seedlings selected from Western Region Department

of Agriculture cacao nurseries.

The cultural treatments are designed to test the possibility of increasing the survival of cacao seedlings through the dry season, and the effects of these treatments on growth. The interaction of these treatments with virus will be of particular interest. The main effect of the Calonectria treatment will be less important than its interaction with the virus and cultural treatments.

Experiment 1.

The experimental area is 0.2 acres of a recent food farm, with a rather sandy soil. The Amazon seedlings were graded in the nursery according to differences in height, and the different groups were associated with blocks at random, when planting, thus increasing precision of the experiment. The seedlings were planted at 3' x 3' without overhead or lateral shade. There are 36 experimental plants in each main plot, and a single guard row between main plots and the five blocks. A heavy grass mulch has been applied to the soil throughout the experiment. There is a 2^2 factorial layout on main plots of irrigation and no irrigation versus fertiliser and no fertiliser. In the irrigated plots the stands are watered after two consecutive days without rain. A fertiliser mixture was applied to the appropriate plots at these rates:-

N, as Urea, at 50 lbs. N/acre/annum
P, as Triple Superphosphate, at 100 lbs. P_2O_5/acre/annum
K, as Potassium Sulphate, at 50 lbs. K_2O/acre/annum
Mg, as Magnesium Sulphate, at 25 lbs. MgO/acre/annum.

The mixture was applied broadcast over the plots up to the guard row.

In a main plot, the virus treatments are allocated to three groups of twelve plants at random. The treatments are:-

A. plants infected with virulent virus
B. plants infected with mild virus
C. healthy controls.

In A and B the plants were infected by patch grafting from virus infected material, plants in treatment C were grafted with patches from healthy seedlings. The Calonectria will not be inoculated until symptoms of virus infection appear.

Experiment 2

An experimental area 0.46 acres which had been bush-fallowed for two years after food farming was clear-felled before

planting and the soil was found to be in slightly better condition than that in the first site. Planting material was a mixture of Amazon and TN38 seedlings which were graded and the groups allocated as before. The design is similar to that of the first experiment, except that the treatments on main plots are artificial shade and no shade versus fertiliser and no fertiliser; there are six replications of the factorial layout. A palm frond canopy at a height of five feet, supported by bamboo poles gives about 35 per cent. shade. Three guard rows were planted between main plots and one guard row round each shaded plot is included under the canopy. The fertiliser mixture, the virus and Calonectria treatments are as in the first experiment. The purposes of the two experiments are substantially the same. The sites are sufficiently close to have similar climatic conditions, and the results should be comparable. Records on both experiments will be taken as follows:-

1. Height, at 2-week intervals
2. Girth, at 2-week intervals
3. Number of leaves, at 4-week intervals
4. Survival percentages.

After twelve months, alternate stands will be thinned, and at harvest the spread of the fungus within the plants measured; fresh and dry weight data for the treatments will be obtained. During the coming year, soil and air temperatures and soil moisture changes will be measured.

WEST AFRICAN FUNGICIDES RESEARCH UNIT

Experimental work on the laboratory programme to evaluate a number of fungicides has continued. Various levels and forms of fungicide deposit are being assessed biologically and chemically. A number of methods for doing this have been investigated. The method of taking sample washings and determining the fungicidal effect in vitro has been rejected, since it is not possible to remove all, or constant proportions, of the fungicide from a known area of pod surface. A method of inoculating pods to cause multiple infections, using a technique in which the minimum redistribution of fungicide deposit occurs, is being investigated (cf. Wharton, Quarterly Report No. 45). Initial results have suggested that unsprayed pods can be infected to give sufficient lesions for the method to be used as a measure of fungicide deposits. First assessments of fungicide deposits on pods using this method, have given promising results, when

compared with chemical determinations.

Work on the optimum condition for the production of sporangia and the liberation of zoospores has continued.

The J.T. Martin method (Martin, J.T. Ann.Rep.Long Ashton Res.Sta. 1956, p.125) for chemical measurement of the copper fungicide deposits has been used both in connection with the laboratory experiments and also in the study of the variation in the deposits on pods during a routine spraying. Mean values for the deposit at lateral positions on the pods at various heights in the trees are listed below: the variations about the means were very wide. The deposits at the distal and proximal position were several times those listed:

0	- 3 ft.	2.8 micrograms/sq. cm.	
5	- 9 ft.	1.4	" " "
12	- 15 ft.	0.5	" " "

It was not possible to follow the natural weathering of these deposits owing to unseasonable dry weather.

A laboratory sprayer for applying even deposits for the chemical and bioassays mentioned above has been built, and some first chemical determinations on evenness of spraying are encouraging.

Sedimentation studies to determine fungicide particle-size ranges for a number of products have been started, and surface tension measurements of fungicide suspensions made.

The visit by the two members of the Unit to the Southern Cameroons has been reported elsewhere.

SOA.